Art. II.—*Some Experiments in Propulsion.*

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The following are particulars of some experiments made at Torbay (England) in February last, by Mr. B. Tower, of Newcastle-on-Tyne, respecting the application of the power represented in the movement of a ship on waves. The experiments were made in the presence of Mr. W. Froude, F.R.S., and Mr. H. Brunel. The vessel in question was a miniature ship of six (6) feet in length, and was lent for the purpose from the Admiralty Works at Torquay. The apparatus used was similar in plan to that of a model exhibited at the Exhibition in Melbourne in 1873, with the exception that a strong metallic spring was employed instead of a pneumatic one. The tension on the spring was such that when the vessel was horizontally placed in smooth water the loaded working beams of the machinery were also horizontal. The relative motions of the load were limited to one dimension only—viz., in a plane at right-angles to the plane of the deck. These relative movements were imparted to a ratchet-wheel, causing it to revolve continuously in one direction. The shaft of the ratchet actuated a large wheel and pinion, and the continuous rotation of the pinion was ultimately conveyed to the screw shaft by an indiarubber band accumulator, which stored up the power transmitted to the screw.

As the vessel was decked, and had only been lent for the trial, the machinery had to be placed above deck, and owing to this it could not be loaded to its full power: a load of only seven pounds being placed on it. This was a serious disadvantage, as, had the machinery been below, a load three times as great would have been placed on it, the power developed being increased in the same proportion. Notwithstanding this, the results completely verified the calculations which had been made respecting the operations of the machinery, the screw on an average making forty (40) revolutions per minute, the vessel attaining a speed of 3½ knots against a head sea and wind. The maximum effect was observed to take place when the play of the load was isochronous with the period of the waves; whenever this occurred the machine worked with great vigour, the screw sometimes making as many as 180 revolutions per minute. It should be remembered, however, that this great speed of rotation of the screw is not the best suited for propulsion, on account of the creation of what is known as negative slip of the screw. Indeed the difficulty throughout in the experiments which have been made is not in obtaining sufficient power, but rather in controlling the excess of it. The wind on the occasion under notice was off shore, the waves therefore very small, about four feet long, and a few inches only in height, with a period of six seconds. The reason why the period of the waves is so important an element in the effect produced, is that the efficacy of the principle depends mainly on the velocity of the movements, not their magnitude, as shown in the fact that the model in question worked vigorously with the movement of only an inch, repeated however ten times per minute. In point of theory the action of the apparatus involves some very abstruse points; indeed it had proved not a little perplexing to those who had witnessed it. Mr. Froude, at the first meeting of the Institution of Naval Architects, 1874, referred to the principles involved in the action of the machine as a very obscure subject; and again, at the British Association at Bristol, September, 1875, he spoke of it as a most complex proposition which he and others had at first only dimly seen through. Mr. G. Rendel also, the distinguished engineer and originator of the "Staunch" class of gun-boats, and the partner of Sir Wm. Armstrong, has referred to the principle of the machine as (to repeat Mr. Rendel's words) a very curious and beautiful idea, and that it has been well worked out; as a scientific principle, he adds, he considers it perfect. Similarly at the April session of the Institution of Naval Architects, Lord Hampton, the President of the Institution, spoke of it as one of the most important, but at the same time most difficult, of projects. It need hardly be added that the development of a principle so little understood as is admitted in these opinions is necessarily a work of slow progress, when every step in the demonstration nearly exhausts for a long time individual means.

The dynamical effect exhibited by the model during the experiments as accurately taken at the time, was at the rate of $1\frac{1}{2}$ horse-power per ton of working load. With regard to this vigour of action, which occasioned some surprise at the time, it may be remarked that the load acquired such a proportion of the large moving force of the water displaced by the ship as the mass of the load bears to the mass of the ship. Thus if 100 tons be employed in a vessel of 1000, the machine acquires 1-10th of the whole moving force of the water displaced ; this being indirectly abstracted, as Mr. Tower well expresses it, from the vast store of energy passing beneath the feet. In other words, every ton becomes imbued with the force with which the same weight of water —*i.e.*, of thirty-five cubic feet—is moving at the time : in the case of a load of 100 tons consequently representing the energy of 3500 cubic feet of water moving with the speed of the wave motion. The considerable effect of this may perhaps be apparent (though the applications are quite dissimilar) by observing the effect of even a sluggish stream in turning a water-mill.

The experiments briefly detailed above have been since repeated in different forms with the same results, and have been admitted to have shown the correctness of the method employed, whatever may be the theory of its action, in applying the energy stored in the movements of the sea. As some doubt was expressed at the British Association (Bristol, 1875) as to the ability of the machine to drive a ship against a head sea, Mr. Froude (who was at the time President of the Mechanical Section) stated that he had himself witnessed the model in Torbay driving itself against and through a head sea which, in comparison with the size of the model, was mountainous. As this refers to a point of importance, the testimony of so distinguished an authority may, I think, be regarded as definitive on the matter. A proposition to which value has been attached is that, given the same bulk and weight, the power developed under ordinary circumstances compares favourably with that of a steam-engine, and under exceptional states of the sea it is very much greater. I think I may say that the very carefully repeated experiments of Mr. Tower do not leave room for doubt on this head. In any case it would appear that, apart from auxiliary propulsion, a useful source of power for many minor purposes at sea exists. As regards pumping, it may be remembered that the power referred to is mostly greatest in those emergencies when it is most required—viz., when a vessel is at the mercy of the elements, and when fires cannot be maintained.